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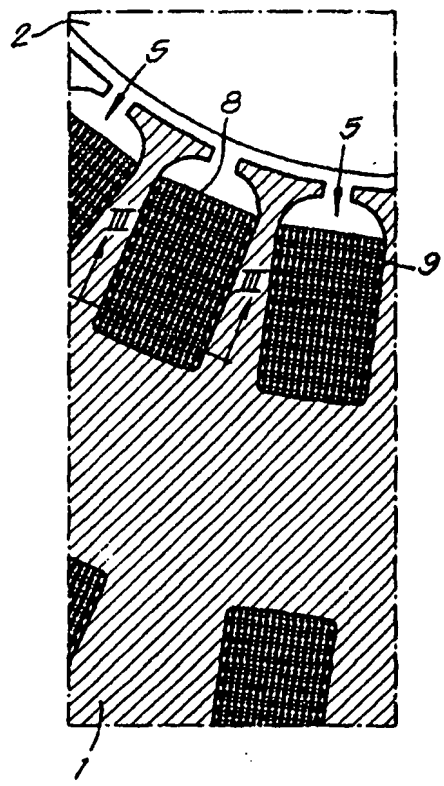
(54) Title: ELECTRICAL MACHINE WITH A WINDING



(57) Abstract: The invention relates to an electrical machine with a winding (5) comprising a wire (8) consisting of individually insulated conductors (9), these conductors being wires or strands, characterized in that the insulated conductors (9) extend in a zigzag pattern between the edges of the winding (5) said edges being in thermal conductive contact with a cooling medium.

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Electrical machine with a winding.

This invention relates to an electrical machine, more particularly a motor or a generator, with a winding comprising a wire consisting of individually insulated conductors, these conductors being wires or strands.

This kind of wire is commonly known as Litz wire.

Such windings are for instance placed around the teeth of the stator or in grooves in the stator, which teeth or grooves extend parallel to the rotation axis of the rotor

In known motors or generators, the conductors of the wire of the winding extend parallel to each other or are twisted in small bundles, which extend parallel to each other. These small bundles may for instance consist of Litz wires having twisted or braided wires, the winding wire comprising several of such Litz wires which extend parallel to each other.

The heat conduction of the winding perpendicular to the direction of the winding is very small compared to the heat-conduction of copper. Therefore the winding is often impregnated with special materials to increase the thermal conductivity, but even then the thermal conductivity in transversal direction of the winding is relatively small and the possible cooling of the winding is limited.

EP-A-0.519.679 discloses a armature winding, the wire used for the winding comprising parallel conductors. In a

traverse section of the winding wire, several conductors are adjacent to each other in the traverse direction and these conductors extend parallel to each other in the longitudinal direction of the winding wire. This document does not mention any cooling and the winding has the same limited cooling possibility as the above mentioned known motors and generators.

The lack of sufficient cooling of the winding may constitute a limit to the speed of the motor or generator.

The invention seeks to provide an electrical machine with a winding having an increased cooling.

In accordance with the invention, this object is accomplished in that the conductors of the winding wire extend in a zigzag pattern between the edges of the winding, said edges being in thermal conductive contact with a cooling medium.

In a section perpendicular to the winding, and in the transversal direction there is only one wire with in zigzag extending insulated conductors.

By the zigzag pattern, the heat can be transferred along the wires to the edge of the winding and so to the cooling medium instead of having to jump through the insulation from one wire to the other and the heat may be dissipated laterally to a much greater extend than when the conductors are parallel.

DE-C-496.884 discloses a method for manufacturing a winding

wire wherein the conductors extend from on edge of the wire to the other. However this document does not disclose how such wire is used in a winding. Nothing is suggested that the edges of the wire are also the edges of the winding and are in thermal conductive contact with a cooling medium. On the contrary, with the purpose of cooling, the winding wire may be made hollow, comprising thus a channel for cooling air.

According to the invention, the zigzag pattern may be under angles between 5° and 45° and preferably between 10° and 30° with respect to the mean longitudinal direction of the winding.

More particularly, the winding wire may consist of a wire formed by a flat and wide packet of insulated conductors, each conductor extending in zigzag from one side of the packet to the other.

The winding may be in heat conductive connection with a solid heat conducting material, for instance the iron of a stator, in which case the cooling medium consists of his heat conducting material.

The winding may be situated in a channel in a stator, whereby in a form of embodiment, space is left open in the channel, which space is filled with a liquid or gaseous cooling medium, for instance transformer oil.

The winding wire may be impregnated with a suitable varnish so that the winding becomes self-supporting. In this case, the winding may be used in an air-wound motor and the

cooling medium may be gaseous.

The invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a part of an electrical motor with a prior art winding with Litz wire;
Figure 2 is a sectional view similar to that of figure 1, but with a winding according to the invention;
Figure 3 represents a section along line III-III in figure 2;
Figure 4 represents a section similar to that of figure 3, but with respect to another form of embodiment of the winding wire;
Figure 5 is a sectional view similar to that of figure 2, but with respect to another embodiment of the winding according to the invention.

Figure 1 shows a portion of a prior art motor comprising a stator 1 surrounding a rotor 2.

The inner side of the stator 1 is provided with teeth 3 between which channels 4 are formed. A coil or winding 5 with a Litz wire 6 is present in each of these channels 4.

The Litz wire 6 consists of a number of individually insulated conductors 7 surrounded by an insulating envelope 7A.

In another embodiment, the Litz wire 6 may consist of a number of bundles of magnet wire surrounded by an

insulating envelope.

In both embodiments, the insulating envelope is not absolutely necessary.

In both embodiments, the wire 6 is wound several times around the stator 1 so that several portions of said wire lie as well adjacent to each other as one above the other. In the transversal direction of the winding several portions of the wire are adjacent and none of the portions is extends simultaneously to both lateral sides of the winding.

This means that heat may very difficultly be dissipated from the conductors 7 situated inside the Litz wire 6. The heat has to jump laterally from conductor to conductor and further from one Litz wire 6 to another to reach the outer surface or edge of the winding 5 an thus the channel 4.

The motor shown in figure 2 only differs from the one shown in figure 1 by a design of the winding 5, which is according to the invention.

The winding 5 consists also of a wire 8 comprising a number of individually insulated conductors 9, but these conductors 9 are extending in zigzag in their channel 4 so that each conductor 9 regularly reaches the outer surface or edge of the winding 5. The conductors 9 may be single wires as shown in figures 2 and 3 or may be strands or bundles.

The zigzag pattern is under angles α between 5° and 45°,

preferably between 10° and 30° with respect to the mean longitudinal direction of the winding 5 and the wire 8.

The conductors 9 may be included in a flat and wide packet with nearly rectangular section as represented in figures 2 and 3, each of the conductors 9 reaching from one side of the packet to the other side, e.g. in the form of a plait.

The packet constituting the wire 8 is as large as the channel 4 and the lateral edges of the packet touch the wall of the channel 4, this is the iron of the stator 1.

There may also be a thin electrical insulation between the wall of the channel 4 and the winding 5, whereby the insulation is so thin that thermal conduction from the conductors 9 towards the wall of the channel 4, which are in heat conducting material of the stator 1, mostly iron, is not prevented.

The packet of insulated conductors 9 may for instance be surrounded by an envelope 8A of electrical insulating material, as shown in the figures 2 and 3.

In fact the wire 8 may be considered as a flattened Litz wire.

Tests have shown that the heat conductivity of the winding 5 with winding wire 8 according to the invention with conductors 9 zigzagging from one edge of the winding to the other, is more than ten times that of the winding 5 according to figure 1 with parallel standard Litz wires.

Thermal paste may be used to improve the cooling of the winding 5 against the iron of the stator 1 or another cold wall.

In another embodiment, the conductors 9 are not held together by an envelope 9A but may be held together in the packet by forming a braid or plait, in which case the envelope may be omitted. This could still improve the heat dissipation. Figure 4 shows such embodiment.

Another embodiment of the motor according to the invention is shown in figure 5. In this case the edges of the winding 5 do no longer touch the walls of the channel 4 and the iron of the stator 1. A space 10 is left in the channel 4 on both sides of the winding 5. This space 10 is filled with a liquid cooling medium such as transformer oil.

Spacers 11 are provided in the channel 4 to keep the winding 5 in the correct position.

This can also be accomplished by impregnating the winding wire 8 by a suitable varnish, whereby the winding 5 becomes self-supporting and thus suitable for air-gap wound motors.

In this case the cooling medium may be gaseous, for instance air blown between the windings 5.

In the embodiment of figure 5, the heat conductivity is even higher than in the embodiment of figures 2 and 3.

The zigzag pattern of the conductors 9 of the embodiments of figures 2 to 5 according to the invention permit the

heat to transfer along the copper conductors towards the edge of the winding 5 and from there to the solid, liquid or gaseous cooling medium.

The electrical machine must not necessarily be a motor. It may for example be a generator.

Claims.

1.- Electrical machine with a winding (5) comprising a wire (8) consisting of individually insulated conductors (9), these conductors being wires or strands, characterized in that the insulated conductors (9) extend in a zigzag pattern between the edges of the winding (5) said edges being in thermal conductive contact with a cooling medium.

2.- Electrical machine according to claim 1, characterized in that the zigzag pattern is under angles (α) between 5° and 45° with respect to the mean longitudinal direction of the winding (5).

3.- Electrical machine according to claim 1, characterized in that the zigzag pattern is under angles (α) between 10° and 30° with respect to the mean longitudinal direction of the winding (5).

4.- Electrical machine according to claim 3, characterized in that the wire (8) is a Litz wire.

5.- Electrical machine according to any one of the preceding claims, characterized in that the winding (5) consists of a wire (8) formed by a flat and wide packet of insulated conductors (9), each conductor (9) extending in zigzag from one side of the packet to the other.

6.- Electrical machine according to claim 5, characterized in that the winding (5) consists of a wire (8) in the form

of a packet of insulated conductors (9) extending in zigzag in the form of a plait or braid.

7.- Electrical machine according to either one of the preceding claims, characterized in that the winding (5) is situated in a channel (4).

8.- Electrical machine according to any one of the preceding claims, characterized in that the winding (5) is in heat conductive connection with a solid heat conducting material, for instance the iron of a stator, in which case the cooling medium consists of his heat conducting material.

9.- Electrical machine according to any one of claims 1 to 6, characterized in that the winding (5) is situated in a channel (4), a space (10) being left open in the channel (4), which space (10) is filled with a gaseous or liquid cooling medium such as transformer oil.

10.- Electrical machine according to either one of the preceding claims, characterized in that it is impregnated with a suitable varnish so that it becomes self-supporting.

11.- Electrical machine according to either one of the preceding claims, characterized in that it is used in an air-gap wound motor and the cooling medium is gaseous or liquid.

PRIOR ART

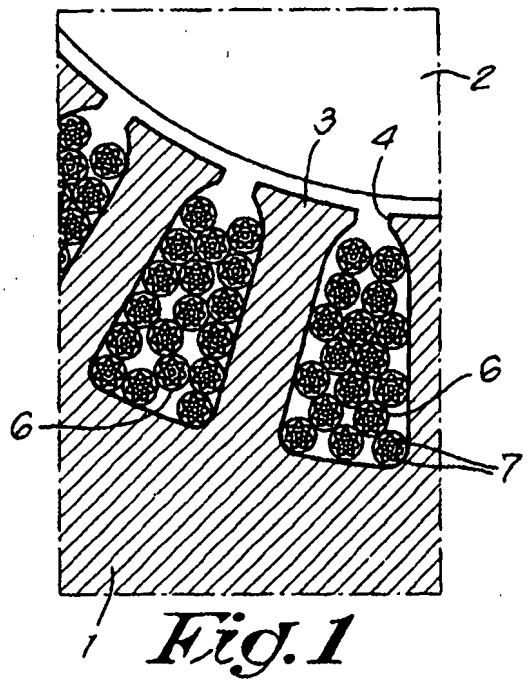

Fig.1

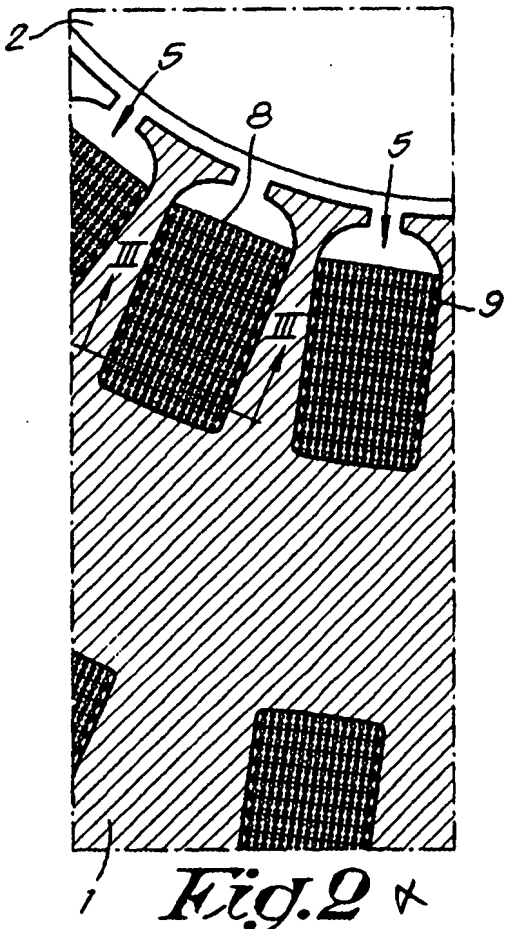

Fig.2

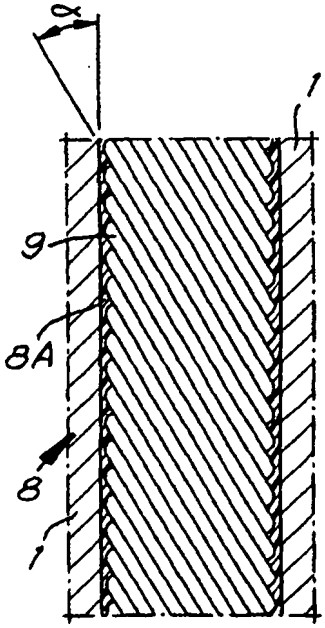

Fig.3

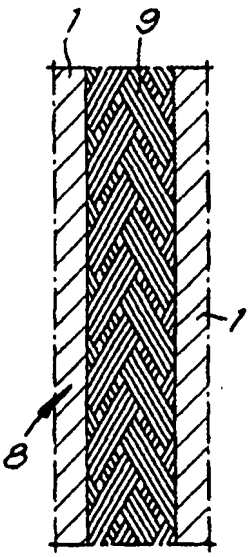

Fig.4

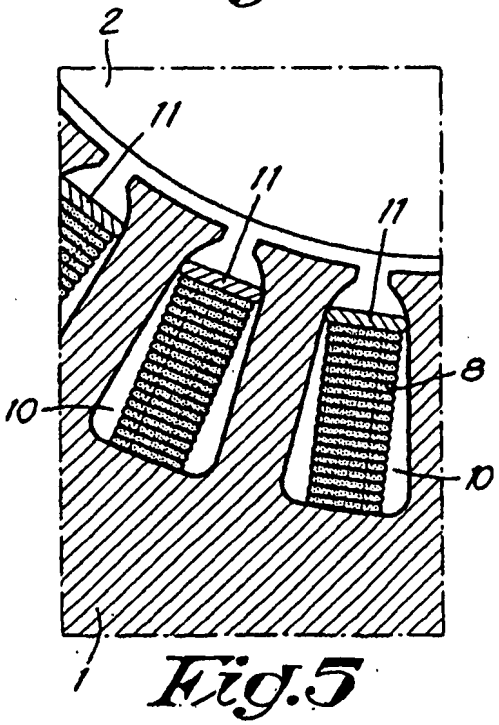

Fig.5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/BE 00/00135

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H02K3/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 496 884 C (SIEMENS-SCHUCKERTWERKE AG) 10 April 1930 (1930-04-10) figures	1
X	EP 0 519 679 A (HONDA MOTOR CO LTD) 23 December 1992 (1992-12-23)	1-6,10
Y	abstract; figures 5,9,22	7-9,11
Y	DE 32 41 506 A (LE PROIZU ELMASH STR OB ELEKTR) 10 May 1984 (1984-05-10) abstract; figures 1,2	7-9
Y	US 4 123 679 A (MIYASAKA TAKAO) 31 October 1978 (1978-10-31) figure 8	11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2001	01/03/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ramos, H

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/BE 00/00135

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 337 567 A (LUGOSI ROBERT ET AL) 6 July 1982 (1982-07-06) column 1, line 53 -column 2, line 14	

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/BE 00/00135

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